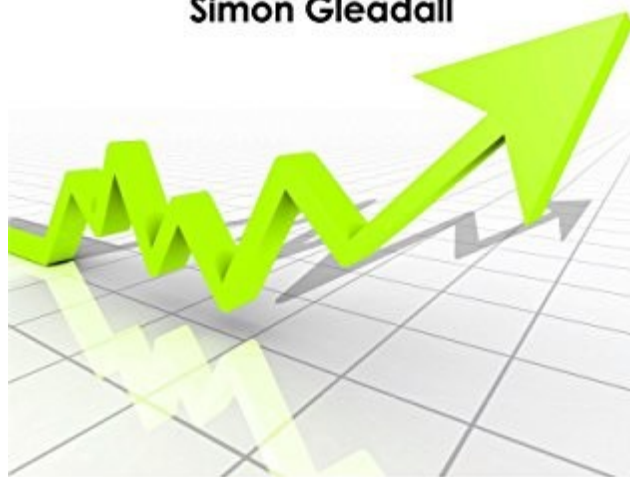


1st Edition

OPTIONS TRADING IN 7 DAYS

Simon Gleadall



volcube

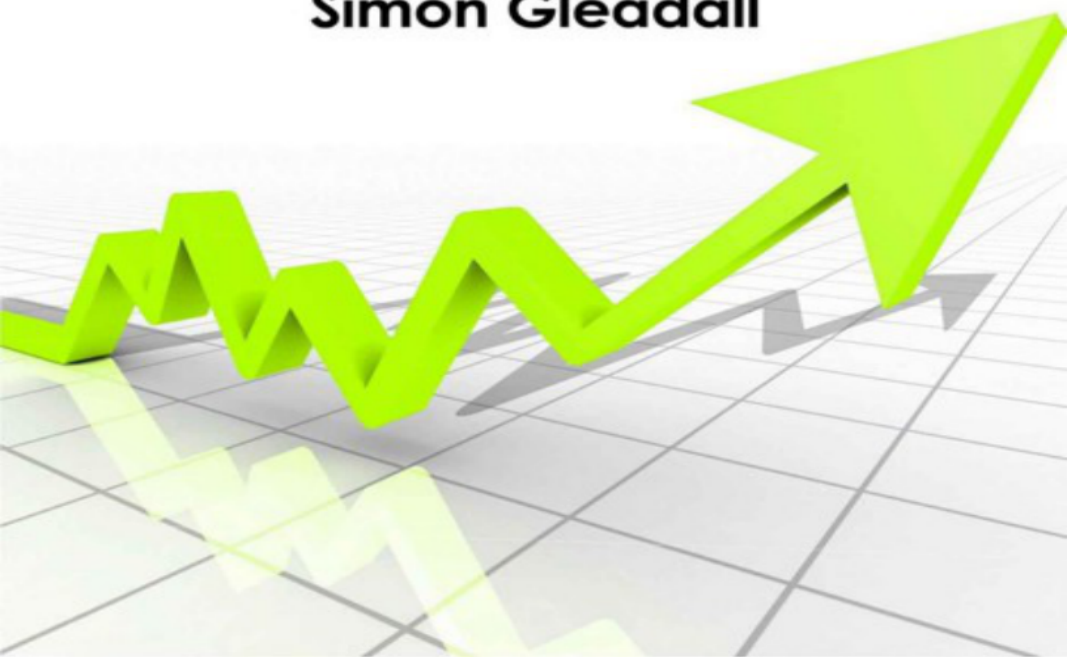
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Options involve risk and are not suitable for all investors. Options transactions are complex and carry a high degree of risk. They are intended for sophisticated investors and are not suitable for everyone.

How to use this book

This ebook can be used as a stand-alone 7 day course in options. No prior knowledge is assumed. Each of the seven lessons includes a set of Exercises with full answers at the back. The lessons introduce options, explain how they function and ways they can be traded. Also considered is how options be valued or priced and their associated risk. The last two lessons focus on options and volatility.

To get the most out of the course, it is recommended that you attempt the Assignments in each lesson. These are performed using the Volcube options simulator and training tool. You can get a free 7 day login to Volcube from volcube.com. You do not need a credit card and your login will just expire automatically at the end of your 7 day trial. Volcube is a powerful options education technology which allows you to play simulated options trading games and also includes useful videos and articles relating to options trading.

A glossary of important option-related terms will be found towards the end of the book. Recommendations for how to continue with an options education are also given.

About the author

Simon Gleadall is one of the co-founders of Volcube and has traded options and other derivatives since 1999. He works closely with the Volcube development team on upgrades to the simulation technology and also co-produces much of the original learning content.

About Volcube

Volcube provides a leading options education technology to firms and individuals who want to learn about professional options and volatility trading. The Volcube technology is a web-based option market simulator with embedded, automated teaching tools and a rich learning library. Volcube was founded in 2010.

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volume V	:	<i>Option Greeks for Traders : Part I : Delta, Vega and Theta</i>

1. Introduction to options

Options contracts traded in the financial markets are ultimately just options! A lot of people think of options firstly as complex derivatives, but the easiest way is to realise that a financial option is just a *choice* about whether to do something, no different to any other option we might have.

So let's think about an option we might encounter in everyday life. Suppose your friend offers you the option to join him at a music concert. Let's consider what this option might mean to you and what might affect its value. Firstly, this option may be *intrinsically* valuable to you. Maybe the concert involves your favourite musicians whom you have waited your whole life to see play. You would certainly think an option to go to this concert is going to be valuable to you. But for how long do you have the option? If the option is only good for this evening, then that is pretty short notice. Maybe you have another engagement and cannot attend. Clearly, it would be a better option if it lasted longer; if your friend can let you join him at the concert any time this week or month, it is a lot more valuable to you. What if your friend cannot be absolutely certain who is playing at the concert? This changes things again. If you cannot be sure it is your favourite musicians playing, going to the concert may not be as great for you as you originally thought. So that *uncertainty* about the outcome of exercising the option, reduces its value in this case.

Let us tidy this up a bit. What we are saying is that if you have the option to do something, the value of that option to you is going to depend on a number of factors. Firstly, whether the outcome from exercising the option is intrinsically good or bad. If I give you the option about whether or not I stamp on your toe, then this option has no obvious intrinsically good value for you whereas the option, say, to receive a free lottery ticket probably is intrinsically interesting to you. Secondly, if there is uncertainty about the outcome, that can affect the value of the option, positively and negatively. Suppose I give you the option that I will either stamp on your toe or give you \$100, with a 50:50 chance of either outcome. This option might be valuable to you (depending on how highly you value your toes); so in this case, increasing the uncertainty of the outcome increases the value of the

option. Thirdly, having an option to do something for longer, is generally more valuable than having it for only a short time. For example, if you have the “get stamped on/get \$100” option for a week, maybe you can go and buy some steel-toe capped boots and then exercise the option? But if the option is ‘now or never’, its value is probably lower to you.

Financial options are not just similar to options like these; they are options exactly such as these. Financial options give you the option, rather than an obligation, to trade something. If you are offered a *call* option, this just gives you the option to buy a product for a certain price by a certain date. The value of this option to you is going to depend on whether the trade is intrinsically valuable (i.e. whether trading the product via the option is better than buying the product in the market), how long you have to exercise the option and also how much uncertainty there is in the price of the product. If the price of the product never changes and the option has no intrinsic value right now, then it never will have intrinsic value (because the price of the product will never move to make the option valuable). But a bit of uncertainty over the future price of the product could make the option valuable now even though it is not *intrinsically* valuable; because the price of the product may rise in the future above the price at which you have the option to buy.

So, what are options? Options in the financial markets are simply choices, no different in essence to the options we have in everyday life. Their terms and conditions are spelled out carefully in the form of a contract and they typically involve actually buying or selling something else. But a lot of the ideas around the pricing and risk of options can easily be understood by simply recognising that financial options are ultimately just options!

Basic definitions

Let’s get some basic definitions under our belt.

Def #1 : An option is the right, but not the obligation to trade a certain amount of a certain product at a certain price on or before a certain date.

Let’s break down Def #1.

*a certain product....*This is the **underlying product** or (**spot product**) to which the option relates.

to trade..... A **call** option gives its owner the option to buy. A **put** option gives its owner the option to sell.

a certain amount.... The contract multiplier. Each option will allow its owner to trade a precise amount of the underlying product; it could be that each option relates to 100 shares or 1 one futures contract for example.

a certain price.... This is called the **strike price** of the option.

a certain date.... This is the **expiration date** of the option. A European option can only be exercised at expiration. An American option can be exercised at any date or time before or up to the expiration. Note that this has nothing to do with geography whatsoever; 'American' and 'European' options trade all around the world!

Examples :

Example 1.1 The 115 puts on company ZXY with a multiplier of 50, expiring on 16th February (European options).

The owner of these puts has the right but not the obligation to sell 50 lots of ZXY shares at a price of 115, on (and not before) the 16th February.

Example 1.2 The \$110 calls on crude oil futures, expiring in August (American options).

The owner of these calls can buy crude oil futures for \$110. They can be exercised any time before the expiration date. The exact date and contract multiplier are not given.

Call and put payoffs

If you trade an option now at a certain price, what will be the profit or loss from this option when it expires? This is the most fundamental question about an option and it is known as the option's payoff profile. When the option expires, the underlying product will be trading at a certain price and we must understand what an option is worth at that price.

Fortunately, this is easy to learn. An option payoff profile can be

calculated with basic arithmetic. Let's start with a call option and look at a simple version of the basic definition.

A call option gives its owner the option to buy the underlying product at a certain price.

At the option's expiration, the owner of the call can decide whether or not to exercise the option. If he exercises, he will purchase the underlying product at the strike price of the call. Is this a good idea? Of course it depends on the price of the underlying product *compared to* the strike price of the call. If the underlying product is worth more than the strike price of the call, then exercising the call option makes sense. The owner of the call will then be buying the underlying product for a price below its current trading price. But, if the underlying product is currently trading *below* the strike price of the call, it does not make sense to exercise the call. Why would he want to pay the strike price for the underlying product if he can simply pay the market price which is lower?

Example 1.3 : A call option has a strike price of 90. At the expiration of the call, the underlying product is trading at 100. Should the owner of the call option exercise the call?

Yes. By exercising the call option, the owner of the call pays 90 for the underlying product which is currently trading at 100, giving a profit of 10.

The value of call options at expiration

The call option in example 1.3 is *in-the-money*. Its strike is below the current underlying product price. What is the value this call at expiration? The call must be worth 10. If the call was trading at a price of 9, then anyone could buy the call (at a cost of 9) and exercise the call (at a cost of 90; the strike price). The result is that they would own the underlying product of a total cost of 99. Since the underlying product is trading at 100, this makes a risk-free profit of 1. So the calls at expiration must be worth 10. If anyone was prepared to pay more than 10, they would be foolish. By paying say 11 for the calls and then exercising (at a cost of 90), they pay a total of 101 for the underlying product which is only worth 100.

So the value of an in-the-money call option at expiration is simply the difference between the strike price and the price of the underlying product. If a call option is not in-the-money (i.e. its strike is not below the current underlying product price), then it is worthless.

Adjusting the payoff for the option trade price

Of course, no option is available for free! Anybody who is prepared to sell an option (or as it is also referred to, *write an option*), will want some compensation for the risk they are taking. If someone buys an option, that amount must be deducted from the payoff, *irrespective of the underlying product price*.

Example 1.4 : John pays \$1.50 the \$120 strike calls. At expiration, the underlying product is trading at \$125. What is John's net profit or loss?

First calculate the value of the option. Then deduct the price paid for the option. The call option is in-the-money (strike < spot price), so its value is $\$125 - \$120 = \$5$. John paid \$1.50 for the call, so his net profit is $\$5 - \$1.50 = \$3.50$.

Profit and loss payoffs for the option seller

The seller of the call option in Example 1.4 has a precise **mirror image** payoff profile to John. He collects \$1.50 from John when he sells the calls, but at expiration the calls are worth \$5, so the seller has made a loss of **\$3.50**.

A note on limited/unlimited payoff profiles

Something important to note that is demonstrated by Example 1.4 is that John's downside (the most he can lose) is limited to the amount he pays for the call. John can never lose more than the \$1.50 he paid because the least the call can ever be worth is zero. However, for the seller of the option, his loss is potentially unlimited. The most he can make from selling the call is the \$1.50 he receives from John. But if the call expires in-the-money, John will exercise the call and the seller's loss is the difference between the spot price and the strike (minus the \$1.50). In other words, the higher the spot price, the more the call seller can lose. This leads to some general rules about call options.

The loss from owning a call option is limited to the amount paid for the option. The gain is potentially unlimited.

The loss from selling a call option is potentially unlimited. The gain is limited to the sale price.

Put option payoff profiles

Puts and calls of the same strike have lots in common with one another (as we shall see in Chapter 2). In terms of payoff profiles, the ideas are very similar. Just remember that a put option is related to *selling* the underlying instead of buying, so the interesting part of the payoff profile is when the underlying price falls below the put option strike.

Let's start above the strike. If, when the put expires, the underlying is trading at a price *above* the strike price of the put, the put is worthless. It is out-of-the-money. Why? Because exercising the put means selling the underlying at the strike price and this is not a good idea if the spot is trading above the strike price. The put owner would be better advised to just sell the underlying product at the higher price, rather than selling via exercising the put.

The put is therefore only valuable if the underlying product price is *below* the strike price at expiration. In such circumstance, the put is worth the difference between the strike price and the spot price. This is exactly analogous to the situation with a call option. But whereas a call option is in-the-money if the spot is above the strike price, a put is in-the-money if the spot price is below the strike.

Adjusting the put profit and loss for the traded price

Just as for call options (or indeed any trade), any put option profit and loss profile needs to be adjusted for the original trade price. When the put has been bought, the price paid must be deducted from the intrinsic value of the put at expiration.

Example 1.5 : John pays \$1 for the 99 strike puts. At expiration, the underlying product is trading at 95. What is John's net profit-and-loss?

The 99 puts at expiration are \$4 in-the-money. They are intrinsically worth \$4. John paid \$1 for the puts, so his net profit is \$3.

Assignment 1.1 : Watch Volcube Quick Start video #1 in Learning

Follow the instructions in your Volcube Confirmation email to login to Volcube. Click on the Learning tab, then choose Videos&Audiocasts from the left hand menu. Choose the Quick Start videos and then

Starter Edition. In here you will find Quick Start video #1 which gives you a 5 minute introduction to using the Volcube application.

Assignment 1.2 : Call/Put Payoff Mini-game

Click on the Game tab in Volcube. Choose Option Minigames from the menu. Select the second game, Call and Put Payoffs. This starts a new game which tests your understanding of call and put payoffs. Answer at least 25 questions and you will then register a percentage score for this minigame. Ideally you should practise this minigame (and indeed every minigame that you will play in Volcube) until you are scoring almost 100%.

Assignment 1.3 : Start a Level 1 options trading simulation

Finally, we are just going to start a Level 1 options trading simulation to whet your appetite for some simulated options trading! Click on the Game tab, then choose Levels. This will show you a Level 1 simulation profile in Volcube. Don't worry too much about all the data you can see. All will become clearer as you progress through this course. For now, just press Single Player on the right hand side and a new Level 1 trading game should start up.

Exercise 1

1.1 Does the buyer of a put option have the right to sell or buy the underlying product?

1.2 Can European options be exercised before expiration?

1.3 John sells an option. Does John have the right but not the obligation to do anything?

1.4 John buys a call option. Does he want the price of the underlying product to rise or fall?

1.5 A call option has a strike of 110. The spot is trading at 85. Is the call in-the-money or out-of-the-money?

1.6 Can a put and a call of the same strike both be in-the-money at the same time?

1.7 The spot product is trading at \$50 when the options expire. Which is more valuable; the \$60 strike calls or the \$60 strike puts?

1.8 John sells the \$110 puts at \$3. The spot product is trading at \$107 when the put options expire. What is John's profit-and-loss?

1.9 John sells a call option. Is his profit-and-loss profile limited or unlimited?

1.10 John pays \$0.50 for the 90 puts and \$0.50 for the 110 calls. If the spot is trading at \$112 at expiration, what is John's profit-and-loss?

2. Option valuation

Optionality prior to expiration

In part 1, we looked at the payoff profiles of options at the moment of expiration. We found that calls or puts had a value of zero if they expired out-of-the-money (or at-the-money). If they expired in-the-money we found that their value was simply the difference between their strike price and the spot price. But what is an option's value *before* expiration? This in fact is the more interesting side to options. At expiration, an option is either worth an obvious, intrinsic amount or it is worthless. But whilst it lives and breathes, different factors affect its valuation.

It can be helpful to think of another kind of option to see what factors influence the value of options generally prior to expiration. Suppose you have the option to use my umbrella and you must decide immediately whether or not to exercise this option. Well, the option to use my umbrella really only has any value to you if you are going outside at this very moment and it is raining. This option, which is expiring imminently, is easy enough to value. But what if I instead offer you the option to use my umbrella at any one time over the next 3 months? What would you pay for this option (i.e. what do you consider its value to be)? Suddenly lots of extra factors come into play. Is it raining right now? Is it going to rain every day over the next 3 months? Are you going outside in the next 3 months? The point is that an option that expires almost immediately is easy enough to value; either it has a value or it does not. This value is known as the *intrinsic value* of an option. For options (whether regarding umbrella usage or trading financial instruments) that have a longer lifespan, the value can also be made up of other components. And it is possible for an option to still have value even when it is not currently *intrinsically* valuable. Even if it is not raining right now, the option to use my umbrella in the next three months may still have a value to you. So it is with financial options; they may not be intrinsically value right now, but that could change before they expire.

Intrinsic & extrinsic value

The value of an option is made up of two components. An option can have *intrinsic value* and it can have *extrinsic value*.

The intrinsic value just tells us the amount an option must be worth by virtue of its strike price in relation to the spot price (and whether it is a call or a put). For example, if the spot is trading at \$100, the \$90 call gives its owner the right (but not the obligation) to buy the spot at \$90. This is \$10 below the current spot price, so the call option must have an intrinsic value of at least \$10. Again, this is so because if the call was trading at less than \$10, it would be possible to buy the call and (in the case of American options) immediately exercise the call in order to buy the spot for a net price *below* where it is currently trading. This is a risk-free arbitrage profit that simply cannot exist in the market (at least not for very long!). So, if the call was being offered for sale at \$5, we could buy the call (paying \$5), exercise it (i.e. pay \$90 for the spot) for a total outlay of \$95. We could then sell the spot back to the market at \$100, making \$5 risk-free profit. (Because in the case of European options, we could simply buy the call and sell the spot product short. When the option expires, we exercise the call option in order to buy back the spot at the cheaper price. In other words, the principle is the same, we just have to wait until expiration for the position to be closed out). So the call must be worth at least \$10 otherwise an arbitrage opportunity exists.

If an option has not yet expired, it can also have extrinsic value. Extrinsic value is that component of an option's value that reflects the fact that the option still has *optionality*. The option to use my umbrella may not have intrinsic value if it is not currently raining. But if rain is expected in the next few months, the option to use the umbrella may still be valuable. So it is with financial options. If the spot product is trading at \$100, the \$90 puts have no intrinsic value. (Who wants to sell something at \$90 when it is trading at \$100?). But if the options have enough time until expiration, they may still have value. Why is this? Well, as per the rain that comes and goes, the price of the spot product may vary. Perhaps in a few months time, the spot will be trading at \$80, in which case the put options are *in-the-money* and have \$10 of intrinsic value. So the extrinsic value captures the optionality component of an option's value. It reflects the value that is owing to the fact that the option could become more intrinsically valuable in the future, because it still has time left until it expires.

Put-call parity

Put-call parity describes an important relationship between puts and calls. Essentially, it suggests puts and call are fundamentally the same thing! But we need to be more specific here about which puts and which calls are so very alike. Put-call parity applies to puts and calls

of the same strike and expiration date, sharing the same underlying product. (In its strictest form, it applies only to options where dividends and carry cost are not a factor; but let's not worry about this for now). What we are saying is that the \$100 puts and \$100 calls on the same spot with the same expiration share everything that is important about options.

To understand why put-call parity holds, it is easiest to recall the payoff profiles of calls and puts. By working through an example of the \$100 calls and \$100 puts and considering the payoff at expiration, you should notice a symmetry. If the spot is trading at \$110, the calls have \$10 of intrinsic value, the puts have \$0 of intrinsic value. With the spot trading at \$90, it is the puts that have \$10 of intrinsic value and the calls that are worthless. Now, it is possible to synthetically recreate the exact payoff profile of the \$100 calls, using the \$100 puts and the underlying. By simply hedging the \$100 puts with the underlying (which we assume is trading at \$100 for now), we create a *synthetic* \$100 call. Suppose we own the \$100 puts and wish to synthetically transform these puts into the \$100 calls. We can do this by simply buying the spot (assume it is trading \$100), one-for-one with the put. Consider what happens to the payoff profile of the hedged put. Versus \$90, the puts still have \$10 of intrinsic value, but the spot trade has lost \$10 (because we paid \$100 and it is now trading at \$90). So overall, the profit and loss is zero with the spot at \$90. With the spot at \$110, the put is worthless but the spot trade makes a profit of \$10; so our net profit and loss is \$10. This is exactly the same payoff profile as the \$100 calls alone.

Put-call parity is a very important result for option traders. It means that in simple cases the only difference in value between a call and a put of the same strike and expiration is the intrinsic value. Intrinsic value is simply the value that the in-the-money option must have by virtue of being in-the-money (i.e. the difference between its strike and the spot price). Extrinsic value contains the remainder of an option's value and, due to put-call parity, it will be the same for puts and call sharing the same strike and expiration.

The three most important factors that affect option value

Many factors affect an option's value before it expires. However, three of these factors usually dominate the valuation and so these are the most crucial to understand.

Important factor #1 : The **spot price** relative to the strike price. Here we are just talking about the intrinsic value of an option. If a call has a strike of \$100 and the spot is trading at \$110, the call must be worth at least \$10. But with the spot at \$90, the call would have zero intrinsic value. So clearly the spot price relative to the strike price is important.

Important factor #2 : The length of **time until expiry**. An option that expires in 5 minutes and is far out-of-the-money, is probably worthless. If an option on the same underlying with the same strike has 12 months until it expires, it could still be valuable. So, other things being equal, the longer an option has until it expires, the more it is worth.

Important factor #3 : The **expected level of volatility** in the underlying product. The more volatile the spot product is expected to be during the life of the option, the more valuable that option, in general, will be. Why is this the case? Well, consider an option that is out-of-the-money and suppose that the underlying product price *never* altered. This option has no chance of ever expiring in-the-money and so it is essentially worthless. Whereas if the underlying product is very volatile, the chances are far higher that the option may finish its life in-the-money. This illustrates pretty simply how the amount of volatility that is expected during an options life in the spot product price positively affects option value. The expected level of volatility is more commonly known as the **implied volatility** level.

Assignment 2.1 : Intrinsic/extrinsic mini-game

Load the Option Mini-game Intrinsic/Extrinsic. You will be presented with four pieces of information and need to calculate the missing field denoted by ????. Remember that the total value of an option is the sum of its intrinsic and extrinsic values. The intrinsic value is either zero for out- (or at-)the-money options or it the difference between the option strike and the spot price for in-the-money options. Attempt at least 25 questions in order to register your score for this minigame.

Assignment 2.2 : Study the Pricing Sheet

Start a Volcube simulation (either via Levels or Custom Play). Consider the Pricing Sheet in the top middle of the pane. In the centre is a column labelled 'Strike'. This shows the strike prices of the different options in this game. To the left of this column, you will see a column labelled CALL THEO. This column shows the *theoretical*

values of call options in this game, given their strike price. To the right of the strike column, you will see the equivalent theoretical value column for puts options. These values have been generated by an options pricing model; a mathematical formula that takes into account the different factors that affect option values and generates a value.

Spend some time studying this pricing sheet. Notice in particular the difference in price between calls and puts *of the same strike*. Remember that when put-call parity holds (as it does in Volcube) the only difference between a put and call's value is the *intrinsic value* of one of the options. The default value of the spot in Custom Play and in Level 1 games is \$100. The \$90 calls have a value of \$10.338. Notice that the \$90 puts are worth \$0.338. The difference between the two options' values is \$10, which is the intrinsic value of the \$90 calls (i.e. the amount by which they are in-the-money).

By considering the Pricing Sheet, a great deal can be learnt about option values and the relationships between calls and puts of differing, and the same, strike.

Exercise 2

2.1 If the spot is trading at \$100, what is the intrinsic value of the \$85 puts? a) \$15 b) 0 c) No-one can say

2.2 If the spot is trading at \$50, what is the extrinsic value of the \$45 calls? a) Zero b) \$5 c) No-one can say

2.3 The \$75 calls are \$5 in-the-money and have \$1 of extrinsic value. What is the value of the \$75 puts (assume same expiration and same underlying as the calls) if put-call parity holds?

2.4 If I buy the \$100 calls and sell the \$100 puts at zero cost (i.e. the prices of the calls and the puts are equal), what is my position equivalent to in terms of the spot product?

2.5 At expiration, do options have extrinsic value, intrinsic value or both?

2.6 What are the three most important factors that affect an option's value prior to expiration?

2.7 Is the intrinsic value of an option dependent on the time

remaining until expiry?

2.8 Are options with longer until expiry more or less valuable than options with shorter lifespans but in all other respects identical?

2.9 A long put option plus long spot position is equivalent to what call position, assuming put-call parity holds?

2.10 Does higher implied (expected) volatility in general increase or decrease the value of an option? Does the change in value affect the intrinsic or extrinsic component of the option's value?

3. Ways to trade options

Options are amongst the most flexible financial instruments in the market. This is because options can be used by investors and traders to accurately reflect their preferences with respect to a number of different factors. For example, options can be used by traders who are bullish on the underlying asset price or bearish or even who are directionally neutral on the price of the underlying. Investors who expect a large movement in the underlying price but are not certain about whether it will be up or down. Investors who already own the underlying and are looking to protect their investment. Traders who want to use options to create an income stream in addition to owning the underlying. All of these situations and many more can be catered for with relatively simple option strategies and portfolios. And this goes some way to explain the popularity of options. Here are some of the most common motivations for trading options.

Using options to trade directionally

Options can be used to gain exposure to the price of the underlying product. This is known as trading options directionally. For example, if an investor is bullish with respect to the price of the underlying product, he might decide to buy some call options to profit from any rally in the spot price. He could, with the same end goal in mind, sell some put options short. Both of these are examples of trading options to gain exposure to the direction of the price of the underlying. Combinations of options (known as option strategies) can be traded to reflect more precise directional biases. For instance a trader who is bullish on the underlying, but only expects a rally up to a certain price and no higher, can trade call spreads (also known as bull spreads) rather than a single call option. The reason to trade a strategy rather than a simple outright is that the more precisely a trader can specify his expectations, the more cost-effectively the option portfolio can be constructed. In the case of a bull spread, the trader partially finances the purchase of one call with the short sale of a call of a higher strike. He limits his upside potential from a rally in the underlying; but if the upper strike is chosen to be beyond the level which the trader reasonably expects to see, then he cannot be sorry. Option portfolios can be built to reflect and profit from almost any permutation of spot price outcomes that the trader expects.

Using options to hedge an existing position

An extension to using options to trade the direction of the price of the underlying, is to protect an existing portfolio against price changes. For example, suppose the investor owns the underlying product and he is concerned that the price will fall. If he sells the underlying product to reduce his portfolio, he of course will not benefit if the underlying product price subsequently *rises*. An alternative is to use options as a form of price insurance. For example, by buying a put option on the underlying, the investor may protect his asset in part or in full against the drop in price. If the underlying product price rises, the investor will still profit by owning the asset but he will lose the premium paid for the put (insurance). So options can be used to alter the risk profile of a portfolio to suit the preference of the investor.

Using options to generate income

Options can be used to generate an income or to enhance the returns of an existing portfolio. The basic idea behind this strategy is that options have extrinsic value which will all be 'lost' by the time the options expire. So, the thinking is that by selling some options, this fall in value can be captured. Of course, there are risks associated with selling options; whilst the extrinsic value owing to time will indeed fall, the *intrinsic* value of the option at expiration

may be zero, but it may be very different from zero. The classic example of this way of trading options is the so-called 'covered call'. The idea is that the owner of some asset (say a stock) can enhance his return on this asset by selling out-of-the-money call options on the stock. If the stock falls in price, he loses money since he owns the stock, but the calls will expire worthless and he will recover some or all of his losses on the stock via this source of income. On the flipside, if the stock rallies, the investor profits from the rise in the stock's value. Of course he may then lose money on the short call position.

As with every trading strategy, this is not a win-win scenario but a risk versus reward trade-off. Nevertheless, options can be used in this way either to enhance a portfolio's return (with skillful management) or at least with the intention of smoothing the returns.

Using options to trade volatility

One of the fundamental reasons for trading options is to gain exposure to or protection against volatility. Recall that one of the three essential components of option value is the expected level of volatility in the underlying product. By hedging away the exposure to the spot price movements (i.e. by delta-hedging), volatility is left as the primary driver of the option's value. Why would traders or investors want to 'trade' volatility? Increasingly, volatility is viewed as an asset class in its own right. As volatility impacts on so many trading and investment strategies, it is now imperative for traders to be able to manage this risk or to capitalise on the opportunities it affords.

Whilst options can be used simply to trade the direction of the spot product, this is rather like only using a car in first gear. To trade volatility via options requires traders to have a fuller understanding of options' capabilities, potential and response to changing risk factors. Mastering any style of options trading requires an essential understanding of options as volatility trading instruments.

Market making options

Market making is an activity where traders are prepared to show a bid price and an offer price in an instrument. Instead of only showing a price they are prepared to pay or only showing a price at which they will sell, market makers always show two-way prices where they are prepared to buy or sell. The buying price they are willing to pay is always lower than the price at which they are willing to sell and they hope to make a profit by consistently buying at the lower price and selling at the higher price. This represents their *reward* for market making. Their *risk* from market making is related to the inventory that they might acquire whilst they are busy buying and selling. For example, if there are a succession of selling orders from the rest of the market to the market makers, then the market maker will start to accumulate a long position. The risk is that the value of these instruments will fall; and if market participants are consistently selling, then a falling price, economics tells us, will be the result. So the market maker of any instrument has to manage the risk associated with the inventory he acquires until he is able to liquidate the position.

Market making options is a core business function of many banks and proprietary derivatives trading firms. They will show bid and ask prices in many different option contracts and manage the risk of any position that accrues. The risks relating to options are many in number, but there are many opportunities and techniques for managing these risks effectively.

Successful option market making requires a very thorough understanding of options; of how they are priced, how they are affected by changing circumstances and how they relate to one another. We shall refer to some of these techniques throughout the remainder of this book. If these can be fully understood, a very large step towards mastering options will have been taken.

Assignment 3.1 Put-call parity Mini-game

Load the put-call parity Mini-game. This will test your understanding of put-call parity in practice. There are instructions on how to play the game alongside each question as well as detailed examples at www.volcube.com/support/volcube-tutorials/. The basic idea is that when put-call parity holds, the difference between the value of a call and put of the same strike, is simply the intrinsic value. The intrinsic value is also the difference between the spot price and the strike price. So these two facts allow us to always calculate either the call value, or the put value, or the strike price or the spot price when we know the other three values.

Assignment 3.2 Play a Level 1 game and enter some quotes

Load a Level 1 trading simulation in Volcube. You will be taken to the Main Game screen for this simulation. In the top right is the Messenger window. The broker should be asking your for a quote in some calls or some puts; something like “Jan 90 puts?” or “Sep 109 calls?”. In the middle section of the Messenger window you will see the options being quoted and the word “Theo:” with a value alongside. This shows you a theoretical value for the options (more on this in the next chapter). In the lower half of the Messenger pane is a pad which allows you to adjust your bid and ask prices and quantities. This allows you to make a quote response to the broker, showing him a price you are prepared to pay for the options and a price at which you are prepared to sell. For now, you can just make the bid price a couple of pennies below the theoretical value and the ask price a couple above. If you then trade on these prices you will make a *theoretical* profit because you are buying below theoretical value and selling above theoretical value. Enter some quotes, perhaps make some trades and get used to the whole process. Welcome to option market making!

Assignment 3.3 Watch Blitz Video #2 : Making a market in options

This video covers some of these basic ideas about bids and offers and market making in general. After watching, try playing more Level 1 games.

Exercise 3

3.1 A hedge fund is short crude oil futures. If they want to hedge the position using crude oil futures call options, would they buy or sell calls?

3.2 Are these directional option plays bullish or bearish? a) long put b) short call c) short put and long call

3.3 In general, are non-delta hedged option positions (e.g. a simple, outright put position) exposed to changes in implied volatility?

3.4 What are the primary risks/exposures to a delta-hedged option position?

3.5 How can options be used to generate income?

3.6 A trader buys a call and a put of the same strike, equal to the current spot price. What is his immediate exposure to a) the price of the spot product b) the expected volatility of the spot product?

3.7 Which statement best characterises the role of a market maker?

- a) Takes significant directional positions
- b) Trades only seldomly and only when they want to
- c) Trades frequently and hopes to minimise their overall position

3.8 Will an option market maker's offer (ask) price ever be lower than his bid price?

4. Pricing options

Prior to the 1960s and 1970s, options were valued largely by intuition alone and they were priced simply by market forces. The price of individual options was determined by the supply and demand in the particular contracts and the risks associated with those options were not fully understood. For directional traders of options (such as agricultural firms looking to hedge price movements in grains) this was not too problematic; because the payoffs at expiration of the options were known as well as the current price, the options were still perfectly usable as a hedging or speculative tool.

This changed with the widespread introduction of mathematical models, most notably the Black Scholes model of 1973 which remains an industry standard. Although it is not vital to understand the inner workings of such models in order to successfully trade options, it is important to understand, at least in part, how they are used, some of the assumptions on which they are built, as well as some of their limitations.

Valuing options with models

An option pricing model will typically take a number of factors that may influence the option's value and combine this mathematically to generate a single *theoretical* value for the option. As discussed in Chapter 2, the most important factors tend to be the price of the spot product, the time remaining until the option's expiration and the volatility in the spot price that will occur over the option's life. Now this latter factor (unlike the others) is unknown, so traders use the level of volatility that they *expect* to occur. Other factors such as the cost of carry or expected dividend yields may be included if appropriate (for example with stock options). By plugging these numbers into the model and by assuming that the price changes in the spot product will, in the long run, resemble certain probability distributions, a value for an option can be computed. Options in the Volcube simulation games are all valued using the Black Scholes pricing model in this very way. Various option pricing tools are available online and it is worth playing around with one to see how option values vary as the inputs change.

It is important to understand the key distinction between the different inputs to the model. Some are generally known with certainty, such as the price of the underlying or the date of expiration. Others are not known for certain and the most important factor in this category tends to be the level of expected volatility. Traders may disagree over the 'correct' value to use and this can be a reason to trade. Traders can look at the price of options and using the model they can *imply* the expected level of volatility that the market is pricing into the options. From this, they may value options as too cheap or too rich and hence decide to trade.

Things to consider when pricing options to trade

Pricing options means different things to different people. Market makers will have a different approach to say directional traders. Nevertheless, many of the considerations are common to all. So here are some things to consider:

The theoretical value of the option. This will be the result of a mathematical model and, remember this, it is subjective and personal to whoever builds/uses the model. Some option traders will make comparisons between their theoretical value and the current market value and arrive at trading decisions. Such as, "Given my theoretical value of this option, I think the market price is too cheap and therefore I will buy". For market makers, the theoretical value is usually taken as a guide and a reference price for previous trades. When market makers make two-way prices (bids and offers) in an option, they usually consider the theoretical value that their model suggests and then consider whether this should be adjusted in any way

because of what they have already seen trading in the market.

The reward of trading the option at a certain price. When considering trading an option at a certain price (either by initiating a trade or by acting as a market maker and showing tradable bid and ask prices), the potential reward from the trade is a key factor. For market makers, this is typically encapsulated by the amount of ‘edge’ they are receiving for the trade, i.e. the difference between the theoretical value and the price at which they are hoping to trade. For example, if a market maker shows a 6 bid in an option that he theoretically values at 7, then his potential reward from trading on his bid price is 1 tick. For other traders, they may look at the potential reward in terms of expiration payoff profiles versus the traded price. Such as, “I can sell this call at 6 ticks and if the spot is trading below the strike price at expiration, I will win the whole 6 ticks. That is my potential reward.”

The risk associated with trading the option. The flip side to reward is risk. How much could we lose from a trade? If the market maker pays 6 when he has a theoretical value of 7, his risk is that the value falls below 6. If this happens, his profit evaporates. How far might the value fall from 7 before the trader has a chance to liquidate the position? And what might cause the value to change? For options, these are reasonably complex issues that only hard work and practice can really teach. The essential point about risk though is always worth bearing in mind when pricing options. What should concern us and guide an assessment of risk are the factors which can influence an option’s future value. More on this in Chapter 5.

The option in the context of any existing position. When a trader is considering a trade, or a market maker shows prices on which he may reasonably be expected to trade, his *existing* inventory has to be a consideration. Does the trade add to or reduce the position? Will the overall risk of the portfolio be higher or lower after the trade? For market makers, this is an essential consideration when pricing options. It also reflects wider issues around market order flow. If the flow of orders has generally been to sell options (to market makers), it is likely that options have become cheaper and that market makers are sitting on option portfolios that are broadly *long* in nature. Traders will therefore have to weigh the risk of adding to this position against the extra reward (in the form of cheaper options). Adjusting pricing to suit a trader’s current book and in a way appropriate for the current flow of orders is a crucial skill that traders must learn to be successful.

Notice that these ideas, at a conceptual level, really apply to almost any asset that one might consider trading. A notion of ‘fair’ or theoretical value, some idea of the risk/reward and one’s current exposure to the asset or market, are all sensible things to assess before pricing or deciding to trade. Options have their own idiosyncrasies of course, but this basic checklist is worth keeping in mind as one begins.

Assignment 4.1 Buy/Sell Mini-game

Load up the Buy/Sell Mini-game in Volcube via the Game tab. This is a simple but effective game to give you a good grasp of market terminology. People new to trading often struggle with the difference between bids, offers, asking prices and people shouting ‘Sold!’, ‘Take ‘em!’ or ‘Yours!’. This game will make sure you become familiar with these essential basics. After 20 or so tries, your current score should appear. Play until you are scoring 100%!

Assignment 4.2 Start a simple Custom Play game. Use Volcube Market Mentor to give you advice on pricing

Start a simulation in Volcube via Custom Play in the Game tab. In the Messenger pane of your

game you will see a green dialogue bubble labelled 'MM'. This is the Volcube Market Mentor which gives you intelligent advice during your game that reflects the current state of play, your existing position and the current market order flow. Use the Market Mentor to gain help on pricing options. You will see a selection of help ideas in the Market Mentor menu, covering what to think about when pricing or even suggesting a sensible price for you in the game you are playing.

Assignment 4.3 Watch Blitz Video #3 : The difference between theoretical and market value

This video explains the difference between theoretical and market value. Understanding this difference in practice is particular important for option market makers or other option volatility traders. It also applies more generally to any traders who use models to generate theoretical values for financial instruments.

Exercise 4

4.1 An option exchange is showing the live market in an option as 6 bid, at 7 offered. Are these theoretical prices or market prices?

4.2 Will all participants in the market have the same theoretical value for an option?

4.3 Which matters more when considering an opportunity to trade: the *risk* of an option or the *reward*?

4.4 Under what circumstances will the theoretical value of an option prove to be the true, accurate and fair value of the option?

4.5 For market makers, how is the theoretical profit and loss from a trade in an option calculated?

4.6 What is the *actual* (or *market*) profit from the same trade?

4.7 A market maker is currently short a lot of options (i.e. he has sold options he does not already own). Will he generally show a) higher bids b) higher offers c) higher bids and higher offers d) lower bids and lower offers?

4.8 What is the reward that a market maker hopes to capture?

5. Managing option risk : the Greeks

The risk to a trader with a portfolio of assets is that the values of those assets change. This is just as true for option traders as it is for stock traders, investment fund managers or indeed asset-owning businesses. What can cause the value of options to change? The value of assets change when there is a change in the factors that affect their value. The value of a house changes when its location becomes more or less desirable or when its owners renovate or let it fall to ruin. For options, there are analogous changes that matter and these are changes to the factors that affect option values (see Chapter 2). For example, when the price of the underlying product changes, this can affect option values (positively or negatively). If the spot price falls, generally speaking calls become less valuable and puts more valuable.

Option traders are able to *quantify* this risk. What this means is that they can determine how a change in one factor will, in dollars and cents, affect the value of an option. This is essential for risk management purposes. It can guide them on the overall magnitude of their risk and also on how to mitigate this risk by hedging appropriately.

What are the Greeks?

Option risk measures are known collectively as the *Greeks*. They are derived from the same mathematical models that generate theoretical option values. The basic Greeks typically tell us how much an option's value will change when a certain other factor changes. For example, option delta tells how much an option's value changes when the spot price changes. It is often given as a percentage number. So we might have a call with a 50% (or 0.5) delta. This means that for every penny the spot rises in price, the call option's value will increase by half a penny. There are Greeks for all of the factors that affect option values such as the spot price, the implied volatility, the time to expiry etc.

With options, things are rarely constant, simple or linear! So an added complication is that the Greeks themselves are not usually constant. For example the option delta is not likely to stay at 50% if something else changes; the 'something else' could be any of the usual important

factors, such as the spot price, the time to expiry, the implied volatility etc. There are Greeks known as 'higher order' Greeks that tell us by how much lower order Greeks will change when something else changes.

To summarise, we measure option risk using the Greeks. These give us actual numbers telling how sensitive our option's values are to certain changeable factors. These Greeks are themselves also liable to change and we can know about the *change* in a Greek by using another, higher order Greek. This may sound convoluted when first encountered, but it is the fundamental basis of good option risk management. Now let's take a closer look at some important Greeks in particular.

Delta, vega, theta and gamma

Delta tells us the change in option value for a change in the spot price. Calls have positive delta and puts have negative delta. If the spot price falls, generally call options are worth less and put options worth more, because of the *sign* of call and put deltas. Delta is an invaluable Greek which tells option traders about their greatest exposure and also informs them on how to hedge this risk away if they so wish. Option market makers use the option delta to delta-hedge, which means to neutralise the risk associated with the spot market moves. For example if a trader buys 100 call options with a 50% delta, then to delta hedge he must *sell* half as many lots of the underlying (50 lots in this case, assuming a one for one contract multiplier i.e. that one option contract pertains to one lot of the underlying). If the spot market now falls by say 10 cents, the option value will decline by 5 cents (because it has a 50% delta). But the hedged trader is covered for this loss by being short half as many lots of the spot product which have fallen 10 cents. Thus, he has neutralised the effect of the spot price movement by delta-hedging.

Vega tells us the change in option value for a change in the expected level of volatility. Vega is positive for both calls and puts. This is because if the spot product is expected to be more volatile, all options have a better chance of finishing in-the-money. (To see this, imagine an out-of-the-money option on a product whose price never really altered nor was it ever expected to; the option would be worthless. But if the expected level of volatility increased, the option could now have a chance of expiring in-the-money). Vega is an important risk measure for traders, particularly for volatility traders or option market makers. Spot price movements can be relatively easily hedged away

(by delta-hedging), whereas changes in implied volatility can only be hedged using other options. Vega is additive for options struck on the same underlying with the same expiration date. This means the vega of two such options that a trader owns can simply be added to give the total, portfolio vega. The vega from any short option position would be subtracted. Vega is often shown as a normalized, dollar amount. For example a portfolio might have a total vega of \$1500. This means that if the implied volatility moves by 1% (and traders usually mean 1% as in from 25% implied volatility to 26%) the value of the portfolio will increase by \$1500. A fall in implied volatility by 0.5% would result in losses of \$750.

Theta tells us the change in option value for a change in the time remaining to an option's expiration. Notice that delta, vega and theta cover the three most important factors that affect option value. Theta is usually normalized to show us the change in option value for the passing of a single day. For example, an option worth \$1.55 might have 30 days until it expires and a theta value of 5 cents. This means that other things being equal the option tomorrow will be worth \$1.50. This fall in value is a result of the option's time value (or its extrinsic value) declining. As time passes, an option's optionality reduces. Theta tells us the dollar-amount of this fall. Theta is additive across options (and not simply options struck on the same product with the same expiration).

Gamma is perhaps the most important *higher order Greek*. Gamma tells us how much an option's delta changes, with a change in the spot price. All options have *positive gamma*. This means that the delta of an option will vary positively with changes in the spot price. For example, suppose a call has a 50% delta, given the current spot price. If the spot price rallies, will the call delta increase or decrease? The delta will increase because the call has positive gamma, meaning an increase in spot price leads to an increase in delta.

For put options, we have to be a little careful because their delta's are negative to begin with. So, as with the call option, an increasing spot price leads to an increasing put delta, but remember this means a *less negative* put delta. For example a put may have a delta of (-)10% at a certain spot price. Suppose the spot price rallies. The put delta will now be smaller in absolute terms (for example (-)5%) although strictly speaking the delta is large (in nominal terms).

Gamma is important to option traders, especially those who are generally aiming to be delta-neutral. An option portfolio can be delta-hedged to become delta-neutral. But if the portfolio has gamma, this

delta-hedge may only be temporarily effective. Gamma is therefore the most important higher-order Greek for option traders to understand.

Assignment 5.1 Play a Level 1 game. Enter a quote response and make a trade. Analyse your risk.

Start a Level 1 Volcube simulation. Respond to the quote request from the broker by showing a bid and an ask in the option strategy he is quoting. Try to trade whatever order he shows you. If there is no order in this iteration, go on to the next iteration and try to trade there instead. Now try to analyse the Risk Detail pane. The Risk Detail is a matrix which would be familiar to all advanced option traders. It shows the value of various option Greeks for your current portfolio. The horizontal row of numbers across the top of the risk matrix shows various different spot prices. The central column therefore shows the value of the various Greeks versus the *current* spot price. Columns to the left of this show the value of Greeks for lower spot prices and columns to the right show Greek values for higher spot prices. Red numbers are negative and green are positive.

Traders will use a risk matrix such as this to give them a detailed insight into their portfolio's risk and character. Start to familiarise yourself with the limit, ask yourself what the numbers actually mean in practise and notice how they change when other different trades are added to the portfolio.

Assignment 5.2 Use Market Mentor to give you advice about option risk.

The Volcube Market Mentor is an in-game intelligent help system that can provide you with real-time advice concerning your current game. As mentioned in part 4, Market Mentor provides advice regarding pricing, risk management, trade selection and understanding market flows. Make some trades in the current game and then study the Risk Detail alongside studying the advice of the Market Mentor. This should increase your understanding of the interpretation and meaning of the option Greeks.

Exercise 5

5.1 A call option has a delta of $+40\%$. If the spot product falls by 30 cents, by how much does the option rise or fall in value?

5.2 An option has a theoretical value of \$1.55. The option has a theta of 5 cents. Other things being equal, what will be the approximate option value 24 hours from now?

5.3 Implied volatility is 25% and an option has a value of \$1.55 and 10 vega. If implied volatility increases to 26%, what is the approximate change in the option's value?

5.4 An option has a value of \$1.55 and 40% delta. It has 10 gamma, defined as the change in delta for a \$1 move in the underlying. If the underlying rallies 20 cents, what is the new option delta?

5.5 A deep in-the-money call has a 100% delta and each call refers to 100 contracts of the underlying. If a trader buys 200 lots of the calls, how would she delta-hedge?

5.6 A trader owns 100 lots of some puts with a -50% delta. These are delta-hedged with a long position of 50 lots of the spot product. The puts have 10 gamma. What is their delta if the underlying rallies by \$1?

5.7 Following the rally in 5.6, what is the net delta of the portfolio? How would the trader restore delta-neutrality?

5.8 Following the re-hedge in 5.7, the underlying falls back \$1. Does the trader need to re-hedge? What is the overall result of his hedging activity?

5.9 Is the owner of the puts in 5.6 – 5.8 long or short theta (i.e. is he paying theta or collecting theta on his position)?

6. Understanding Implied Volatility

To move beyond the simple reading of option values in relation to the spot price and strike price, it is necessary to understand one of the fundamental drivers of option value. Implied volatility is a key factor that lies behind much of the trading that occurs in option markets. Indeed in some market, implied volatility in percentage points is spoken of in preference to option prices in dollars and cents, such is its importance to options professionals.

What is implied volatility?

We have seen how one of the most important factors determining option value is the *expected* volatility in the price of the spot product. In the simplest cases, this is a particularly important factor because it is generally unknown with any certainty. The current price of the spot product is usually public knowledge. Likewise, the expiration date of options is part of the option contract and there is no confusion or uncertainty. The level of volatility in the spot price that will occur in the future is however a matter of opinion and a reason for traders to disagree about the value of an option. When two traders disagree about the value of an instrument, they have a reason to trade; one thinks the instrument too cheap, the other too rich. Expected volatility, and difference of opinion thereon, is thus a primary reason to trade options.

The expected volatility is known more commonly as the implied volatility. This is because the value of an option (given by a theoretical model) must be associated with a single level of expected volatility. So it should be possible to take the price of an option (in dollars and cents) and use the model to *imply* the expected level of volatility that was plugged into the model to arrive at the valuation. Consider this analogy. Suppose a car is known to be able to drive 100 miles given a full tank of fuel. If we set off and the car drives 50 miles before running dry, this obviously *implies* there was half a tank of fuel when we departed.

Implied volatility is useful in at least two respects. Firstly, it gives a gauge of what the option market is implying with respect to expected volatility in the spot product. If options on a stock are trading at 25% implied volatility (also known as “implied vol” for short) then this implies traders expect that stock to move around with an *annualized* volatility of about 25% over the life of the options. Traders may have a view on whether this seems too high, too low or about right and they can trade the options to create an exposure that matches their view. Secondly, it acts as a unique reference point for the price of options, as we shall now see.

Implied volatility and the price of options

How does implied volatility affect option valuations and option prices? It is always worth considering extreme cases when trying to assess the effect on options of a change in a key variable. Suppose the implied volatility is zero. In other words, the spot product is not expected to change price *at all* over the life of the option. Here, the options would have no extrinsic value whatsoever. Out-of-the-money options will have no value because they are expected to always remain out-the-money since the underlying price is not expected to move in order for them to become in-the-money. Options that are currently in-the-money would be worth their intrinsic value but no more.

Let's consider the other extreme. Suppose implied volatility is extremely high (say many

hundreds of %). In this case options over a very wide range of strikes will be valuable because their chance of expiring in-the-money is expected to be high. The underlying is expected to be highly volatile and therefore strikes currently out-of-the-money still have a strong likelihood of expiring valuably.

The relationship between changes in implied volatility and option prices is encapsured by an option's vega. Vega tells us by how much an option's value (in dollars and cents) changes for a change in implied volatility in percentage terms. For example, suppose an option has a value of \$1.50 given implied volatility of 25%. Suppose the option has 10 vega. What is the option's value if implied volatility increases to 25.5%? The vega of an option is typically normalized so that it shows the change in option value (in ticks) for a 1% change in implied volatility. So in this instance, the option will be worth \$1.55 after the increase in implied volatility; a five cents increase give 10 vega and a $\frac{1}{2}$ % change in implied vol ($10 * \frac{1}{2} = 5$ cents). As we would expect, higher implied volatility leads to a higher option price (as discussed above). It should be mentioned that option vega is not a constant (few things are in the options world!) and can change due to several factors. However, for small moves in the underlying or over short time periods, it is often fine to assume vega is roughly constant when computing changes to option values.

Assignment 6.1 Play the vega/vol/value mini-game

This mini-game ensures you are completely comfortable with the relationship between an option's value, its implied volatility and its vega, by asking you to calculate either the starting or the finishing level of the option's theoretical value or implied volatility. The critical formula to remember and use is :

$$\text{Option vega} = \text{Change in option value} / \text{Change in implied volatility}$$

This can of course be rearranged in two other useful ways.

$$\text{Change in implied volatility} = \text{Change in option value} / \text{Option vega}$$

and...

$$\text{Change in option value} = \text{Option vega} * \text{Change in implied volatility}$$

A detailed example of this option mini-game is available at www.volcube.com/support/volcube-tutorials/.

Assignment 6.2 Play a Level 1 game. Aim for good pricing accuracy.

In this assignment you will play through a simulation aiming for good pricing accuracy. What does this mean? Your Pricing Sheet in the Main Game screen displays the values of calls and puts calculated using *your* model and *your* implied volatilities (displayed on the Pricing Sheet in the far left column). At the start of the game, these implied volatilities accurately reflect the market's perception of implied volatilities in your game. However, as the game proceeds, the market may start to value implied volatility differently. This will be noticeably if for example the broker tries to continually buy options from you (implied volatility is 'going bid' ie increasing). You should aim to adjust your quote responses to the broker by an amount that reflects how far you think implied volatility has moved. This will make your pricing more

accurate. For example, suppose you have the \$100 strike calls theoretically worth 3.15 with 12.6 vega and a theoretical implied volatility of 25%. If the broker sells these to you at 3.09, you have paid roughly $\frac{1}{2}$ a vol ie 24.5% for the calls (from the above formulae, the change (i.e. the difference between your value and the price traded) in option value is about 6 ticks and the vega is about 12, so the difference in implied vol is roughly $\frac{1}{2}\%$).

Start a Level 1 Volcube simulation. Try to play the game for at least 25 quote requests and note your Volcube Pricing Accuracy Metric in the Analysis screen. In the Performance tab of the Analysis screen you will see your accuracy for every quote entered. Play some more games and see if you can improve this score.

Exercise 6

6.1 Other things being equal, if two spot products are identical except that spot A is expected to be less volatile than spot B, would we expect options on A to be more or less valuable than options struck on B?

6.2 If a product's option values are very low, all things considered, is the spot product expected to move a great deal? Is implied volatility in the options therefore likely to be high or low?

6.3 Far out-of-the-money options have low levels of vega. Intuitively, why is this the case?

6.4 An option has a vega of 20 and is theoretically valued at \$4.50 with an implied volatility of 23%. If implied volatility increases to 24%, what is the new option value?

6.5 An option was valued at \$4.50 and had a vega of 20 and an implied volatility of 23%. However, it is now valued at \$4.40. Has implied volatility risen or fallen and to what level?

6.6 An option was worth \$2 with implied volatility at 10%. Implied vol has risen to 10.25% and the option is now worth \$2.30. What is the option's vega?

7. Trading options and volatility

Trading implied volatility via options

Recall the three main drivers of an option's value:

- The price of the spot, relative to the strike price of the option
- The time remaining until the option's expiration
- The expected volatility in the spot product.

Now, unless an option is getting close to expiration, then the impact of the passing of time happens relatively slowly. An option that has plenty of time (weeks or even months) until it expires, will not see its value change dramatically for small changes in time. This is certainly not true for very short-dated options (such as those with only days or hours until expiration), but for any longer term option than these, time's passing is not a major driver of changes in value.

This leaves the spot price and the expected volatility as the key factors. But here again, it is possible to, at least temporarily, minimise the impact of one of these factors. It is possible to hedge the option such that changes in the spot price do not cause the portfolio as a whole to make or lose money. In other words, to all but eliminate the risk associated with changes in the spot price. This is known as delta-hedging. Delta-hedging a portfolio eliminates the short-term risk to an option (or options) owing to the spot price changing. The net result is to concentrate most of the exposure towards the volatility component.

This is most easily shown by an example. Consider a call option with around 1 month until it expires. Suppose the spot is trading at \$100.00 and the \$100 strike call (i.e. the 50% delta, at-the-money call) is theoretically worth \$3.15, with an implied volatility of 25%. Let's suppose an option trader pays \$3.15 for the call; but really it is the 25% implied volatility level he is interested in. Maybe he thinks this level is cheap compared to the actual volatility he expects in the spot price over the coming weeks. Or perhaps he thinks he can sell the

calls later with an implied volatility greater than 25%. Whatever the reason, he will need to eliminate some of the other risks to focus his exposure on the implied volatility level. The most pressing of these risks is the delta risk. It is the most pressing because the spot price is generally the most volatile of all the risk factors. A one-month option will typically not lose value minute-by-minute simply due to time passing (theta risk; indeed these options described only lose about 4 cents per night due to time erosion). But in one minute the spot can move considerably. So this is usually the most urgent risk factor to address. To delta-hedge and 'lock-in' the 25% vol level, the trader needs to sell the spot in a certain quantity at \$100.00. This raises three questions; why does he *sell* the spot, what is the 'certain quantity' and why at price of \$100.00?

Why does he sell the spot?

The value of the call is a positive function of the spot price. If the spot rallies, the call's value will increase. Its value falls, if the spot falls. Owning the call option therefore brings a positive delta exposure to the spot product price. To eliminate this risk, the trader must sell the spot product. If he had sold the call short, he would need to buy the spot. If he had bought a put, he would need to buy the spot to be delta-hedged. The direction of the hedge trade (i.e. whether to buy or sell) must simply aim to offset the exposure of the option.

What is the size of the delta hedge?

The size of the hedge depends on a few factors. The option to be hedged has a delta. This reflects its sensitivity to changes in the spot price. A call option with a delta of 50% ($\frac{1}{2}$) needs to be hedged with 1 lot of the spot for every 2 options. But this must also be modified for the option contract multiplier. If each option contract gives the right to trade say 100 lots of the underlying (contract multiplier = 100), then the delta hedge must be multiplied by 100. So suppose a trader buys 50 lots of the -25% delta puts which have a contract multiplier of 10. The delta hedge involves *buying* $50 * 0.25 * 10 = 125$ lots of the underlying.

Why a price of \$100.00?

Remember that an option's implied volatility maps uniquely to its theoretical value. In other words, an option with a theoretical value of x , must have a single, associated implied volatility of say y . And these two also map uniquely to a single spot price. So we can say that the

calls are theoretically worth \$3.15 with the spot trading at \$100.00 and that this means the calls have an implied volatility of 25%. With the spot trading at \$100.01, the calls will be worth \$3.155 (because the calls have a 50% delta and the spot is trading 1 cent higher, so the calls are worth an extra 0.5 of a cent). The implied volatility will still be 25%; nothing has happened to alter it. So, *in implied volatility terms*, we can say that trading the calls at \$3.15 with the spot at \$100 or trading the calls at \$3.155 with the spot at \$100.01, amounts to the same thing. However, trading the calls at \$3.15 with the spot at \$100.01 does **not** equate to the same level of implied volatility. In fact trading the calls at \$3.15 with the spot at \$100.01 means trading a slightly lower implied volatility level ($< 25\%$). The calls are cheaper, in implied volatility terms. This can be seen using an option pricing calculator (or in a Volcube simulation by deselecting the Live Price checkbox in the Pricing Sheet and entering a different spot price in the white box in the far right).

To calculate the difference in implied volatility between the two different levels of the spot, we can use a rearrangement of the vega formula. The difference in implied vol is the difference in the option value divided by the option vega. If these calls have a vega of say 12.6, then trading them at prices 0.5 cents apart is $(0.5/12.6 =)$ 0.04% vols different. So buying the \$100 strike calls for \$3.15 with the spot at \$100.01, is equivalent to buying 24.96% implied vol, rather than 25%. This may not be immediately obvious, so be sure to work through this example several times and the Exercise below. The key point is that the spot price, option price and option implied volatility match uniquely. So trading an option at a price of p and hedging with the spot at a price of s , ‘locks-in’ the implied volatility level traded at one unique level, i . *Change any one of these three and at least one of the other two must also change.*

This can be easier to portray through simple examples than prose. So the exercise at the end of this chapter is well worth working through and hopefully all will become clear.

Delta-neutral trading

A delta-neutral trading strategy is one that aims to eliminate the (short-term) exposure to changes in the spot price, thus focussing the exposure on other option-related factors. In particular, a delta-neutral trading strategy usually means in implied volatility trading strategy. Examples would be option market making, so-called volatility ‘arbitrage’, or relative-value implied vol strategies or ‘dispersion

trading' (trading implied volatility of a basket of stocks against an index). The role of *actual, realized* volatility may or may not feature in these strategies. It is possible to trade implied volatility as a factor in its own right. Or it may be traded against actual volatility. For more on this topic, see the Volcube Advance Options Trading Guide volume IV, *Trading Implied Volatility*.

We can very briefly outline the premise behind an options strategy to illustrate implied vol trading. An options market maker is prepared to buy or sell options at any given moment. His bid price will be below his selling (or *offer*) price. He hopes to buy low, sell high and pocket the difference. His risk is that buyers are not equally matched by sellers and he ends up with inventory; inventory whose value moves against him.

For instance, suppose a market maker shows a bid and an offer in some calls, when his theoretical implied vol for the calls is 25%. The broker hits the market maker's bid and they trade. So the market maker has bought some options. Suppose he delta-hedges these calls. This locks-in a certain level of implied volatility, say 24.5%. Now suppose a different broker requests a price in some similar options. Perhaps put options with a strike close to that of the calls and a very similar theoretical implied volatility; perhaps 25.2%. The market maker will again show a bid and an offer, but he will probably do so mindful of the level in implied volatility he has already traded. If he can sell the puts at say 25.5%, he will offset some of the option Greek risks from the calls he bought, *and* he will be trading for a profit, in *implied volatility* terms. Buying 0.5% vols under theoretical in the calls and selling a similar strike put 0.3% over theoretical, creates a spread position for a theoretical gain of 0.8% vols. The premise of the strategy is that changes in implied volatility will, generally, be similar for closely related options. Ultimately the trader will look to sell the calls back to someone and buy back the puts from someone else. But in the meantime, this position is nicely spread off and it would require dramatic movements in implied volatility across the curve of options for this position to lose money. The risk would be that instead of someone kindly buying the offsetting puts after the market maker has bought the calls, more sellers of options appear. In this case, the general price of options is likely to fall. Without the offsetting short put position, the market maker is therefore exposed to losses; he will lose money if the value of implied volatility falls below 24.5%, since this is the price he paid.

Assignment 7.1 Play a complete Level 1 game.

In Volcube Level 1 you must trade as a market maker, showing bid and offer prices. As you trade with the broker, try to estimate the implied volatility level you have traded. This is simplified in Level 1 because the spot price is fixed at \$100.00. Your option trades are automatically delta-hedged. So if you trade the at-the-money calls (which have 25% theoretical implied volatility) for say 3.10, this is 5.6 cents (ticks) below their theoretical value. 5.6 divided by the option vega of 12.6 (which you can see in the Pricing Sheet on the right) gives 0.44. This means that 3.10 is equivalent to trading at roughly 24.56% vol. By quickly calculating in this way, you can price and trade options accurately.

Assignment 7.2 Use the Volcube Analysis screen to analyse your performance

The Volcube Analysis screen offers ample feedback for you to review and improve. The TPI (Trader Performance Index) gives your performance an overall score. If you can score 100 or more on a regular basis, that is good progress. Clicking the circled 'R' will reveal a Report, giving more detail about your performance. There are plenty of other metrics available to assess your pricing accuracy, competitiveness and speed. Use the Risk/Reward tab to compare your profitability with the degree of risk you took during the game. The Performance tab can give you more insight into the Competitiveness and Accuracy of all your quotes.

Exercise 7

7.1 An option is worth \$1.50 with 25% theoretical implied vol and 6 vega. What is its new value if the theoretical implied volatility is increased to 26%?

7.2 An option is theoretically worth \$3.20 with 20% implied volatility and 10 vega. If a trader pays \$3.10 for the option, what theoretical value for implied volatility has he bought?

7.3 A trader makes a market in some puts worth \$2.00, with implied vol at 10%. The options have 8 vega. The trader shows \$1.98 bid, at \$2.02 offered. What equivalent implied vol levels is he bidding and offering?

7.4 A trader can pay \$1 for an option theoretically worth \$1.05 with 15 vega. Or he can pay \$1.50 for an option theoretically worth \$1.60

with 10 vega. Both options have theoretical implied volatilities of 20%. Which trade is cheaper in implied volatility terms?

7.5 The spot is trading at \$100.00 when the trader pays \$3.10 for some at-the-money call options he has theoretically valued at \$3.15 with implied vol of 25%. The calls have 10 vega. The trader delta hedges the trade. Later in the day, the spot is trading at \$99.90. Someone is trying to buy the calls, paying \$3.10. If the trader sells his calls at \$3.10, can he make a profit?

7.6 What implied volatility levels would the trader in 7.5 buy and sell if he executes both trades?

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Solutions to Exercises

Exercise 1

1.1 Sell.

1.2 No.

1.3 No. The owner of the option has the right but not the obligation to do something. John may (or may not) have the obligation to do something (if the owner of the option exercises his option). If you are short an option, it is out of your hands!

1.4 Rise. Via the call, John has the right to buy the spot at a fixed price (the strike price of the call). So, the higher the spot price rallies, the more money John will make.

1.5 Out-of-the-money.

1.6 No. If the call is in-the-money, the put is out-of-the-money and *vice versa*.

1.7 The puts are worth \$10. The calls are worthless.

1.8 Zero. John breaks even because the puts are worth \$3, which is the same as the price he sold them for.

1.9 In theory, it is unlimited. The higher the spot price is at expiration, the more the calls are worth and the more money John can potentially lose.

1.10 \$1 of profit. Combinations of options are known as option strategies. Their payoff profiles can be calculated by assessing the individual 'legs' of the strategy and summing. In this case, the puts are worthless (out-of-the-money) and John paid \$0.50, so he loses \$0.50. The calls are worth \$2 and John paid \$0.50 for these, so on the calls he shows a net profit of \$1.50. Overall, his profit is a 50 cents loss on the puts and a \$1.50 profit on the calls, hence a net profit of \$1.

Exercise 2

2.1 Zero. The puts are out-of-the-money and therefore have no intrinsic value.

2.2 No-one can say. Extrinsic value depends on several factors, but the price of the spot relative to the strike price does not reveal it.

2.3 \$1. The puts must have zero intrinsic value because they must be out-of-the-money when the calls are in-the-money. The extrinsic value of the put and the call must be same since they have the same strike and we are told put-call parity holds.

2.4 Equivalent to being long the underlying from a price of \$100. To see this, draw a payoff graph, with the spot price on the x-axis and the profit and loss on the y-axis, for the \$100 strike put (short position) and call options (long position), assuming they were traded at a price of zero. The combination of the two positions should just resemble an upward sloping line, which is identical to the payoff profile of a long position in the underlying, from a price of \$100.

2.5 At expiration, options have no extrinsic value remaining. They may have intrinsic value if they are in-the-money. Otherwise, they have no value whatsoever.

2.6 The spot price, the time until expiry and the expected (implied) volatility.

2.7 No. The intrinsic value only depends upon the strike price versus the current spot price.

2.8 Longer dated options are more valuable than shorter dated options, other things being equal.

2.9 Use payoff graphs to prove this if required. But in simple terms, owning the put and the underlying is synthetically equivalent to owning the call (of the same strike).

2.10 Other things being equal, higher implied volatility means higher option value. Changes to implied volatility alter the extrinsic value of an option. Only a change in the spot price can affect the intrinsic value.

Exercise 3

3.1 Buy calls. Short futures is a bearish position.

3.2 a) bearish b) bearish c) bullish

3.3 In general, yes. Implied volatility is one of the factors that determines option values. Changes in its level will generally affect option values.

3.4 Changes in implied volatility and changes in the time remaining to expiry are probably the most significant risks to a delta-hedged option position. Spot moves can have an impact via gamma effects (see chapter 5 for more on this).

3.5 Because the time-value (extrinsic) value of options diminishes over time, selling options can be a way to generate an income-yielding position. As the time-value erodes gradually, the position profits from being short an asset whose value is falling. There are of course significant risks to such a position which must be fully understood.

3.6 a) His immediate exposure to changes in the spot price is small/very close to zero. This is because the change in spot price affects the call and put values in opposite, and almost equal, ways. So, a rising spot causes the call to rise in value (making a profit for its owner) but the put of the same strike will fall in value by a similar amount (making a loss for its owner). Owning both options therefore results in a position with minimal exposure to (small) changes in the spot price.

b) Here the exposure is significant. Since puts and calls are both affected by changes in expected volatility positively, any change in expected volatility will result in both the put and the call changing value in the same way. A rise in expected volatility will increase the value of both the put and the call. There is no hedging effect as in part a). This option strategy is known as a 'straddle'; the purchase (or sale) of a put and call of the same strike on the same underlying and it is known more as a volatility play than as a short-term directional play.

3.7 c.

3.8 Never. Else the broker could make money from the market maker by trading on both sides. If the market maker offers at 5 but bids 7 for example, the broker could buy from the market maker paying 5 and sell to the market maker at 7. By paying 5 and selling 7 simultaneously, the broker is left with a risk-free arbitrage. Hence, the market maker's bid will always be lower than his ask (offer).

Exercise 4

4.1 These are market prices.

4.2 It is very unlikely. Even if participants use the same model, they may well use different inputs and therefore arrive at a different output.

4.3 The question does not make much sense. Risk and reward must always be considered relative to one another; knowledge of either is insufficient by itself to inform a trading decision.

4.4 When the assumptions of the model that generate the theoretical value prove to hold perfectly.

4.5 The theoretical profit is the difference between the traded price of the option and its theoretical value. If a market maker pays 6 cents for an option he theoretically values at 7 cents, his theoretical profit is 1 cent.

4.6 The actual profit is the difference between the market value of the option and the traded price. If the market maker pays 6 cents and the market values the options at 7.5 cents, the actual profit is 1.5 cents. The market value is often taken to be the mid-price of the best bid and offer price currently in the market.

4.7 Generally speaking, he is likely to show c) higher bids and higher offers. Higher bids, because he will probably be biased towards buying back options when he is short. Higher offers, because he is already short options and therefore will require more reward than before in order to sell more.

4.8 The bid-ask spread.

Exercise 5

5.1 A fall of 12 cents.

5.2 \$1.50.

5.3 Increase of 10 cents to \$1.65.

5.4 The new delta is 42%. 20 cents is one fifth of \$1, so the delta increases by one fifth of 10. Gamma is positive for puts and calls.

5.5 By selling 20,000 lots of the underlying.

5.6 -40%. Gamma is positive so the delta increases (i.e. becomes less negative) with a rally in the underlying.

5.7 The trader is equivalently net long 10 lots of the underlying. He is long 50 lots of the spot and synthetically short 40 lots via the puts (which he owns and which now have a -40% delta). So to restore delta-neutrality he must sell the 10 lots (which is better than having to buy 10 lots, given that the spot market is now \$1 higher than it was).

5.8 If the spot re-traces back down \$1, the puts will again have a -50% delta. But the trader is now only long 40 lots of the spot (because he sold 10 of the original 50 that he owned when re-hedging his delta following the rally). So now the trader is net *short* 10 lots of the underlying (short 50 lots synthetically via the 50% delta puts and long 40 lots of actual spot). The trader needs to buy back the 10 lots he sold to restore delta-neutrality.

The net result is that the trader has the same position he started with before the rally and retracement of the spot. But he has locked-in a \$10 profit, by selling 10 lots of the spot \$1 higher and then buying them back versus the unchanged spot price.

This is known as gamma hedging. The trader was long gamma via his delta-hedged puts and was able to make a profit from movements in the spot price via re-hedging.

5.9 The trader will be long theta, which is to say he is paying theta. He puts will, other things being equal, be worth less tomorrow than they are today. This is the flip-side to having the opportunity to gamma hedge profitably. Long options bring long gamma which can be profitably re-hedged, but the cost of this gamma is the theta time-decay or erosion in the portfolio's value as time passes.

Exercise 6

6.1 Less valuable. The higher the implied volatility, the more valuable the option, other things being equal.

6.2 No. Options are more valuable when the underlying is expected to be volatile as they have more chance of expiring in-the-money. Implied volatility is likely to be low.

6.3 Low vega means that the option values do not change much for changes in implied volatility. This is because for far out-of-the-money options, a small change in implied (ie expected) volatility is unlikely to greatly increase their chances of expiring in-the-money. Vega is the measure of responsiveness of an option's value to changes in implied volatility, hence far out-of-the-money options have low vega.

6.4 Assuming the vega is constant for small changes in implied volatility, the new value is \$4.70.

6.5 Implied volatility has fallen to 22.5%. A 10 cent decline in option value, with a vega of 20 must mean a $\frac{1}{2}\%$ point drop in implied volatility.

6.6 The vega is 120. Since the option has risen by 30 cents for a $\frac{1}{4}\%$ point increase in implied volatility, it would increase by 120 cents for a 1% point increase (which is the definition of normalized option vega).

Exercise 7

7.1 \$1.56.

7.2 19%. 10 cents (below value) divided by 10 vega = 1% difference in implied vol.

7.3 The market is 0.5% of a vol wide ($2.02 - 1.98 = 4$ ticks. Divide this by the 8 vega). The market is symmetric around the value of \$2.00 (since the bid is 2 ticks below the value and the offer 2 ticks above). Hence the market is equivalent to showing 9.75% bid, at 10.25% offered, in implied vol terms. Note that in some option markets, quotes are given in implied vol terms rather than in dollars and cents.

7.4 The second trade is cheaper. The first trade means buying 5 cents under value with 15 vega, which is $\frac{1}{3}$ of a vol point under value; 19.66%. The second trade means buying 10 cents under value with 10 vega, which is 1% vol point under value; 19%.

7.5 Yes, the trader can make a profit. It may seem counter-intuitive because he paid \$3.10 and now he will sell at \$3.10 which clearly is p&l neutral. The profit is realised via the delta-hedge trades. When the trader bought the calls, he sold the spot at \$100.00. When he sells the calls, he will take off the delta-hedge; in other words buy back the spot, paying \$99.90. Essentially he has bought at one implied volatility level, and sold at a higher level.

7.6 The trader paid \$3.10, which was 5 cents below the value of \$3.15. The theoretical implied vol was 25% and the vega 10, so the trader paid $\frac{1}{2}$ a vol below the theoretical (5 cents/10 vega) = 24.5%. When the spot drops to \$99.90, we can assume the call will be worth around \$3.10, theoretically. This is because the call was at-the-money and so had a 50% delta. Hence a 10 cent drop in the spot will cause a 5 cent drop in option value. Remember, the implied volatility does not change simply because the spot has moved slightly. So selling \$3.10 when the options were theoretically worth \$3.10, is simply selling the theoretical implied vol level; 25%. In summary, the trader bought 24.5% vol and sold 25%, making 0.5% of a vol in profit. 0.5% of a vol is a 5 cent profit (on a 10 vega option). The trader made 10 cents profit on his delta hedge. But remember that his delta-hedge was only half the size of the option trade, since the delta was 50%.

Glossary

ask - The selling price. Also known as the offer price. A trader whose ask is 7, is prepared to sell at a price of 7.

at-the-money - An option whose strike price is equal to the current spot price.

bearish - To expect a price to fall.

bid - The buying price. A trader whose bid is 6, is prepared to pay 6.

bullish - To expect a price to rise.

contract multiplier - The number of lots of the underlying to which an option contract pertains. For instance, a multiplier of 100 means that each option confers the right to trade to 100 lots of the underlying.

long - Owning. To be long something is to own it.

lot - A unit of a product. 100 options might be referred to as 100 lots. Selling 10 futures might be referred to as selling 10 lots. The contract multiplier of an option will be specified in a number of 'lots' of the underlying.

offer - See 'ask'. Offer and ask are synonymous.

out-of-the-money - Any option that is not intrinsically valuable given its strike price and the current spot price. For calls, this is any option with a strike above the current spot price. For puts, it is any option whose strike is below the current spot price.

short - To own negative amounts of something. To sell short is to sell something which one does not currently own. Short positions are usually reflected with negative amounts of inventory.